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**UTILITY  
PATENT APPLICATION  
TRANSMITTAL**

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First Named Inventor or Application Identifier

Mamoru Shinohara

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ADDRESS TO: Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

**APPLICATION ELEMENTS**

See MPEP chapter 600 concerning utility patent application contents.

**ACCOMPANYING APPLICATION PARTS**

1. ☒ Specification Total Pages 30
2. ☒ Drawing(s) (35USC 113) Total Pages 3
3. ☒ Declaration and Power of Attorney Total Pages 4
- a. ☒ Unexecuted(original or copy)
- b. ☐ Copy from prior application (37CFR 1.63(d))  
(for continuation/divisional with Box 14 completed)
- [Note Box 4 Below]
- i. ☐ **DELETION OF INVENTOR(S)**  
Signed statement attached deleting Inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
4. ☐ Incorporation By Reference (usable if Box 3b is checked)  
The entire disclosure of the prior application, from which copy of the oath or declaration is supplied under Box 3b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

5. ☐ Assignment Papers (cover sheet & documentation)
6. ☒ Letter under 37 CFR 1.41(c).
7. ☐ English Translation Document (if applicable)
8. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
9. ☒ Preliminary Amendment
10. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
11. ☐ Small Entity ☐ Statement filed in prior Application, Status still proper and desired
12. ☒ Certified copy of Japanese priority application No. P11-323051 filed November 12, 1999

14. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) ☐ of prior application No:

**CLAIMS AS FILED**

	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) BASIC FEE \$710.00
TOTAL CLAIMS	20	20		18.00	0.00
INDEPENDENT CLAIMS	03	2		80.00	0.00
	ANY MULTIPLE DEPENDENT CLAIMS? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO				0.00
				TOTAL FEE	\$710.00

☒ The Commissioner is hereby authorized to charge any additional fees which may be required in connection with this application, or credit any overpayment to ACCOUNT NO. 19-3140. A duplicate copy of this sheet is enclosed.

☒ A check in the amount of \$710.00 to cover the filing fee is enclosed.

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Date: November 13, 2000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**PRELIMINARY AMENDMENT ACCOMPANYING APPLICATION**

APPLICANT: Mamoru Shinohara ATTY. DOCKET NO. 09792909-4686

SERIAL NO.

DATE FILED:

INVENTION: "SEMICONDUCTOR APPARATUS FOR FINGERPRINT  
RECOGNITION"

Assistant Commissioner of Patents  
Washington, D.C. 20231

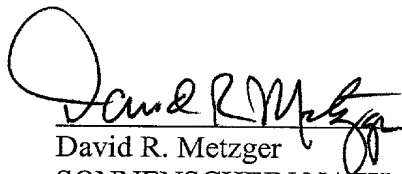
S I R:

Between the title and the heading "Background of the Invention" on page 1, insert the following:

--RELATED APPLICATION DATA

The present application claims priority to Japanese Application No. P11-323051 filed November 12, 1999, which applications<sup>is</sup> are incorporated herein by reference to the extent permitted by law.

Respectfully submitted,



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# SEMICONDUCTOR APPARATUS FOR FINGERPRINT RECOGNITION

## BACKGROUND OF THE INVENTION

### Field of the Invention

5       The present invention relates to a semiconductor apparatus. More particularly, the present invention is concerned with a semiconductor apparatus for fingerprint recognition used as a capacitive mode fingerprint sensor.

### Description of the Related Art

10       In recent years, the fingerprint matching system, which has conventionally been utilized in the applications of the administration of entrance and exit and the like, is being attracting attention as a security  
15       system for the computer network and a personal identification tool in a portable terminal or the like. Examples of fingerprint detecting methods using the fingerprint matching system include an optical detection method, and a capacitive sensing method disclosed in  
20       Japanese Patent Application Laid-Open Specification No. 4-231803, whose basic application is GB9011163 which is also a basic application of USP 5,325,442.

25       The capacitive sensing method is one in which an electrostatic capacity value between the electrodes in the fingerprint sensor is detected, and has an advantage in that the apparatus employing the capacitive sensing method is easily down-sized, and therefore, this method is advantageously mounted on a portable terminal and the like. Thus, the development of the capacitive mode  
30       fingerprint sensor is energetically progressed.

FIG. 4 is a diagrammatic cross-sectional view of a

semiconductor device for fingerprint recognition, which constitutes the above-mentioned capacitive mode fingerprint sensor.

On a substrate having formed thereon a semiconductor device constituting the sensor, such as a transistor or the like (see FIG. 5A described blow), a barrier metal comprised of titanium (Ti) or the like is formed. On the barrier metal, electrodes 52 comprised of, for example, aluminum or the like are formed so that they are arranged in a matrix form and connected to the above-mentioned semiconductor device. Further, pad electrodes 52a are formed simultaneously with conducting the step of forming the electrodes 52.

An insulating protecting film 53 is formed so as to cover both of the electrodes 52 and the pad electrodes 52a, and an opening portion is formed in each of the pad electrodes 52a. Thus, a fingerprint recognition semiconductor chip 51 using, as a fingerprint-recognizing surface, a region in which the electrodes 52 are arranged in a matrix form is formed.

The pad electrodes 52a formed in the fingerprint recognition semiconductor chip 51 and the lead 55 are connected to each other by a wire bonding 54.

While exposing the fingerprint-recognizing surface (upper surface) of the fingerprint recognition semiconductor chip 51 to the outside, the wire bonding 54 which connects the fingerprint recognition semiconductor chip 51 and the lead 55 is encapsulated by a mold resin 56 comprised of, for example, a thermosetting resin or the like.

Next, an explanation is made on the principle of the

operation of the semiconductor device for fingerprint recognition.

FIG. 5A is an enlarged, cross-sectional view of the portion of the electrodes (corresponding to reference numeral 52 in FIG. 4) which are formed in the semiconductor chip (corresponding to reference numeral 51 in FIG. 4) of the semiconductor device for fingerprint recognition so that they are arranged in a matrix form.

On a substrate 10 having formed thereon a semiconductor device constituting the sensor, such as a transistor (not shown) or the like, a barrier metal 20 comprised of Ti or the like is formed. On the barrier metal 20, charge storage electrodes 21 comprised of, for example, aluminum or the like are formed so that they are arranged in a matrix form and connected to the above-mentioned (not shown) semiconductor device on the substrate. An insulating protecting film 30 is formed so as to cover the charge storage electrodes 21.

As shown in FIG. 5A, when a finger 7 is in contact with the fingerprint-recognizing surface of the semiconductor apparatus for fingerprint recognition, a capacitor is formed between the charge storage electrodes 21, the insulating protecting film 30 and the finger 7. The insulating protecting film 30 functions as a part of the capacitor insulating film. In the construction mentioned above, the distance  $d$  (for example,  $d_1$ ,  $d_2$ ) between the charge storage electrodes 21 and the finger 7 varies depending on fingerprint unevenness 70. Accordingly, a difference in capacity is caused between the capacitors which constitute the fingerprint sensor and which are formed to be arranged in a matrix form, and

thus, the charge stored in each of the charge storage electrodes 21 is read and detected by the semiconductor device formed on the substrate 10, such as a transistor or the like, making it possible to recognize a fingerprint.

In the above semiconductor apparatus, each of the charge storage electrodes 21 constitutes a unit cell of the fingerprint-recognizing surface of the semiconductor apparatus for fingerprint recognition.

In a state such that the finger is not in contact with the fingerprint-recognizing surface, the capacitors constituted by the charge storage electrodes 21 and the like have a "d" value which is infinite ( $\infty$ ) in all of the unit cells of the fingerprint-recognizing surface of the semiconductor apparatus for fingerprint recognition. Therefore, in all of the unit cells, the electrostatic capacity value  $C_s$  is zero (0).

On the other hand, in a state such that the finger is in contact with the fingerprint-recognizing surface, as shown in FIG. 5B, in the n-th unit cell, a capacitor having an electrostatic capacity value  $C_{sn}$  is formed between the charge storage electrodes 21, the insulating protecting film 30 and the finger 7. The electrostatic capacity value  $C_{sn}$  is represented by the formula:  $C_{sn} = \epsilon \cdot \epsilon_0 \cdot S/d_n$ . In this formula, S is an area contributing to the capacitor of each electrode,  $d_n$  is a distance (for example,  $d_1, d_2$ ) between the electrode of the n-th unit cell and the finger, and n is the number ( $n = 1, 2, \dots$ ) of the unit cell.

In the construction for reading the electrostatic capacity value  $C_{sn}$  in each of the unit cells, the

capacitor formed between the charge storage electrode 21 of each unit cell, the insulating protecting film 30 and the finger 7 is connected to one source-drain region of the transistor which is gate-controlled by, for example,  
5 a word line WL (WL<sub>1</sub>, WL<sub>2</sub>, ...), and another source-drain region is connected to a bit line BL (BL<sub>1</sub>, BL<sub>2</sub>, ...), and further, a capacitor having an electrostatic capacity value CB is connected to the bit line BL.

In the above construction, when a finger is in  
10 contact with the recognition surface in a state such that a potential V<sub>cc</sub> is applied to the bit line BL (V<sub>cc</sub> precharge), a potential change represented by the formula:  $\Delta V_n = [C_{sn}/(CB + C_{sn})] \cdot V_{cc}$  is caused in the bit line BL. The potential change  $\Delta V_n$  is detected in each of  
15 the unit cells, and the electrostatic capacity value C<sub>sn</sub> per unit cell is calculated, so that the fingerprint recognition is conducted by image processing or the like.

However, the conventional semiconductor device for fingerprint recognition mentioned above poses a problem  
20 in that, when a finger is in contact with the fingerprint-recognizing surface, the static electricity charged in the human body is discharged in the electrodes 52 (21) and a large amount of a current flows through the electrodes 52 (21) into the detecting circuit formed on  
25 the same semiconductor substrate (see FIG. 5B), so that the circuit is damaged and the function as the semiconductor apparatus for fingerprint recognition is lost.

On the other hand, as mentioned above, the  
30 insulating protecting film 53 (30) for the surface of the semiconductor apparatus for fingerprint recognition

functions as a part of the capacitor insulating film of the capacitor formed between the electrodes 52 (21), the insulating protecting film 53 (30) and the finger 7. Therefore, a range within which the thickness of the insulating protecting film 53 (30) is increased and the material for the insulating protecting film 53 (30) is changed for the purpose of suppressing the damage of the circuit due to the discharge of static electricity is inevitably limited.

#### SUMMARY OF THE INVENTION

In this situation, the present inventor has made extensive and intensive studies with a view toward solving the above-mentioned problems accompanying the prior art. As a result, it has unexpectedly been found that the semiconductor apparatus comprising: a substrate having a transistor; a first electrode formed on the substrate and connected to the transistor; a second electrode formed on the substrate and electrically separated from the first electrode; and an insulating film formed on the substrate so as to cover the first electrode, wherein, when a plane of the insulating film which is not on a side of the substrate is taken as a first plane, a surface facing the first plane of the first electrode is taken as a first surface, and a surface facing the first plane of the second electrode is taken as a second surface, a distance between a surface of the substrate and the second surface is larger than a distance between the surface of the substrate and the first surface is free from the above-mentioned problems accompanying the prior art semiconductor apparatus.



Specifically, by virtue of having the above unique structure, the semiconductor apparatus of the present invention is advantageous in that, when a finger or any other material which is electrostatically charged is brought closer to the substrate, the static electricity is not discharged into the electrode but into the static-electricity drawing wiring and then drawn out of the semiconductor apparatus, so that the semiconductor devices, the circuits and the like which are connected to the electrode can be prevented from suffering a damage due to the static electricity and from losing the functions thereof. The present invention has been completed, based on the above novel finding.

Accordingly, it is an object of the present invention to provide a semiconductor apparatus which is advantageous in that, when a finger or any other material which is electrostatically charged is brought closer to the substrate, the semiconductor devices, the circuits and the like which are connected to the electrode can be prevented from suffering a damage due to the static electricity and from losing the functions thereof.

It is another object of the present invention to provide a semiconductor apparatus for fingerprint recognition which is advantageous in that, when a finger which is electrostatically charged is brought closer to the fingerprint-recognizing surface, the semiconductor devices, the circuits and the like which are connected to the electrode can be prevented from suffering a damage due to the static electricity and from losing the functions thereof.

## BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the present invention will be apparent to those skilled in the art from the following description  
5 of the presently preferred exemplary embodiments of the invention taken in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic cross-sectional view of a semiconductor apparatus for fingerprint recognition  
10 according to the first embodiment of the present invention;

FIG. 2 is a diagrammatic cross-sectional view of a semiconductor apparatus for fingerprint recognition  
15 according to the second embodiment of the present invention;

FIG. 3 is diagrammatic cross-sectional view of a semiconductor apparatus for fingerprint recognition  
according to the third embodiment of the present invention;

20 FIG. 4 is a diagrammatic cross-sectional view of one example of a conventional semiconductor apparatus for fingerprint recognition; and

FIGs. 5A and 5B are explanatory views of the principle of the operation of the fingerprint recognition.  
25

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinbelow, preferred embodiments of the semiconductor apparatus for fingerprint recognition of the present invention will be described in detail with  
30 reference to the drawings, but the embodiments should not be construed as limiting the scope of the present

invention.

In the preferred embodiment, on a substrate 10 having formed thereon a semiconductor device constituting a sensor, such as a transistor or the like, a barrier metal 20 comprised of Ti or a stacked film, such as a Ti/TiN/Ti film, is formed, as shown in FIG. 5A. Further, as shown in FIG. 1, electrodes 2 comprised of, for example, aluminum or an aluminum alloy, such as aluminum silicide, are formed on the barrier metal 20 so that they are arranged in a matrix form and connected to the above-mentioned semiconductor device (not shown). Further, pad electrodes 2a are formed simultaneously with conducting the step of forming the electrodes 2.

An insulating protecting film 3, such as a passivation film, is formed so as to cover both of the electrodes 2 and the pad electrodes 2a, and an opening portion is formed in the upper surface of each of the pad electrodes 2a. Thus, a fingerprint recognition semiconductor chip 1 using, as a fingerprint-recognizing surface, a region in which the electrodes 2 are arranged in a matrix form is formed.

The pad electrodes 2a formed in the fingerprint recognition semiconductor chip 1 and the lead 5 are connected to each other by a wire bonding 4.

While exposing the fingerprint-recognizing surface (upper surface) of the fingerprint recognition semiconductor chip 1 to the outside, the wire bonding 4 which connects the fingerprint recognition semiconductor chip 1 and the lead 5 is encapsulated by a mold resin 6 comprised of, for example, a thermosetting resin or the like.

Next, an explanation is made on the operation of the above-mentioned semiconductor device for fingerprint recognition.

The principle of the operation of fingerprint  
5 recognition of the present invention is substantially the same as that of the prior art technique, and is explained with reference to FIGs. 5A and 5B.

FIG. 5A is an enlarged, cross-sectional view of the portion of the charge storage electrodes 21  
10 (corresponding to numeral 2 in FIG. 1) in a matrix form of the semiconductor device for fingerprint recognition.

On a substrate 10 having formed thereon a semiconductor device constituting a sensor, such as a transistor (not shown) or the like, a barrier metal 20  
15 comprised of Ti or the like is formed. On the barrier metal 20, charge storage electrodes 21 comprised of, for example, aluminum or the like are formed so that they are arranged in a matrix form and connected to the above-mentioned (not shown) semiconductor device on the  
20 substrate. An insulating protecting film 30, such as a passivation film, is formed so as to cover the charge storage electrodes 21.

As shown in FIG. 5A, when a finger 7 is in contact with the fingerprint-recognizing surface of the  
25 semiconductor apparatus for fingerprint recognition, a capacitor is formed between the charge storage electrodes 21, the insulating protecting film 30 and the finger 7. The insulating protecting film 30 functions as a part of the capacitor insulating film. In the construction  
30 mentioned above, the distance  $d$  (for example,  $d_1$ ,  $d_2$ ) between the charge storage electrodes 21 and the finger 7

varies depending on fingerprint unevenness 70.

Accordingly, a difference in capacity is caused between the capacitors which constitute the fingerprint sensor and which are formed to be arranged in a matrix form, and thus, the charge stored in each of the charge storage electrodes 21 is read and detected by the semiconductor device formed on the substrate 10, such as a transistor or the like, making it possible to recognize a fingerprint.

In the above semiconductor apparatus, each of the charge storage electrodes 21 constitutes a unit cell of the fingerprint-recognizing surface of the semiconductor device for fingerprint recognition.

In a state such that the finger is not in contact with the fingerprint-recognizing surface, the capacitors constituted by the charge storage electrodes 21 and the like have a  $d$  value which is infinite ( $\infty$ ) in all of the unit cells of the fingerprint-recognizing surface of the semiconductor apparatus for fingerprint recognition.

Therefore, in all of the unit cells, the electrostatic capacity value  $C_s$  is zero (0).

On the other hand, in a state such that the finger is in contact with the fingerprint-recognizing surface, as shown in FIG. 5B, in the  $n$ -th unit cell, a capacitor having an electrostatic capacity value  $C_{sn}$  is formed between the charge storage electrodes 21, the insulating protecting film 30 and the finger 7. The electrostatic capacity value  $C_{sn}$  is represented by the formula:  $C_{sn} = \epsilon \cdot \epsilon_0 \cdot S/d_n$ . In this formula,  $S$  is an area contributing to the capacitor of each electrode,  $d_n$  is a distance (for example,  $d_1$ ,  $d_2$ ) between the electrode of the  $n$ -th unit

cell and the finger, and  $n$  is the number ( $n = 1, 2, \dots$ ) of the unit cell.

In the construction for reading the electrostatic capacity value  $C_{sn}$  in each of the unit cells, the capacitor formed between the charge storage electrode 21 of each unit cell, the insulating protecting film 30 and the finger 7 is connected to one source-drain region of the transistor which is gate-controlled by, for example, a word line WL ( $WL_1, WL_2, \dots$ ), and another source-drain region is connected to a bit line BL ( $BL_1, BL_2, \dots$ ), and further, a capacitor having an electrostatic capacity value CB is connected to the bit line BL.

In the above construction, when a finger is in contact with the recognition surface in a state such that a potential  $V_{cc}$  is applied to the bit line BL ( $V_{cc}$  precharge), a potential change represented by the formula:  $\Delta V_n = [C_{sn}/(CB + C_{sn})] \cdot V_{cc}$  is caused in the bit line BL. The potential change  $\Delta V_n$  is detected in each of the unit cells, and the electrostatic capacity value  $C_{sn}$  per unit cell is calculated, so that the fingerprint recognition is conducted by image processing or the like.

With respect to the semiconductor apparatus for fingerprint recognition which is operated as mentioned above, the first embodiment of the present invention is described with reference to FIG. 1.

FIG. 1 is a diagrammatic cross-sectional view of a semiconductor apparatus for fingerprint recognition according to the first embodiment of the present invention, which constitutes a capacitive mode fingerprint sensor.

In the present embodiment, a wiring 301 for drawing

static electricity (hereinafter, frequently referred to as "static-electricity drawing wiring 301") having a thickness larger than that of an electrode 2 is formed along the line in the longitudinal direction of the electrode 2 (so that the lower surfaces of the wiring 301 and the electrode 2 are aligned in this example). The static-electricity drawing wiring 301 is formed electrically independently from the electrode 2.

An insulating protecting film 3, such as a passivation film, is formed so as to cover the electrodes 2, the static-electricity drawing wiring 301 having a thickness larger than that of the electrode 2, and a pad electrodes 2a, and an opening portion is formed in the upper surface of the pad electrode 2a. Other portions in the present embodiment are the same as the corresponding portions in the prior art (FIG. 4).

The semiconductor device for fingerprint recognition of the present embodiment can be produced by, for example, the following method.

First, a semiconductor device, such as a transistor, which functions as a reading circuit, is formed on a semiconductor substrate, and then, aluminum or an aluminum alloy, such as aluminum silicide, is deposited on the semiconductor substrate by a sputtering process so as to have a thickness of about 1.5  $\mu\text{m}$ .

Then, a resist film for the patterns of a static-electricity drawing wiring and at least one pad electrode is formed by patterning by means of a photolithography process, and subjected to etching, such as reactive ion etching (hereinafter, frequently referred to simply as "RIE"), so that a static-electricity drawing wiring

comprised of aluminum or the like is formed so as to be disposed between electrodes which are formed by patterning in the subsequent step so that they are arranged in a matrix form. At the same time, at least one pad electrode is formed in a form such that it is connected to the static-electricity drawing wiring.

Next, a Ti layer or a stacked film, such as a Ti/TiN/Ti film, is deposited by, for example, a sputtering process so that it is connected to the above semiconductor device, and further, aluminum or an aluminum alloy, such as aluminum silicide, is deposited by a sputtering process so that the total thickness of the resultant film becomes about 0.5  $\mu\text{m}$ .

Then, a resist film for the patterns of the above-mentioned static-electricity drawing wiring and at least one pad electrode, an electrode, and a pad electrode for taking a signal out or the like is formed by patterning by means of a photolithography process, and subjected to etching, such as RIE, to thereby effect patterning so that a stacked film comprised of a barrier metal layer, such as a Ti layer, aluminum and the like is left on the static-electricity drawing wiring and at least one pad electrode, and on the remaining region, the electrodes and the pad electrodes for taking a signal out or the like are arranged in a matrix form.

Next, an insulating film, such as a stacked film of silicon nitride or silicon oxide, is deposited by, for example, a chemical vapor deposition (hereinafter, referred to simply as "CVD") process so as to have a thickness of about 1  $\mu\text{m}$ , to thereby form an insulating protecting film 3. An opening portion through which the



pad electrode 2a is exposed to the outside is formed in the insulating protecting film 3 by patterning. Then, the resultant device is subjected to dicing treatment, to thereby form a fingerprint recognition semiconductor chip 1.

Subsequently, the pad electrode 2a and a lead 5 which is subjected to silver electroplating treatment or the like are connected to each other by a wire bonding 4 using, for example, a gold line or the like.

Then, while exposing the fingerprint-recognizing surface of the fingerprint recognition semiconductor chip to the outside, the semiconductor chip 1 and the wire bonding 4 are encapsulated by an encapsulation mold resin 6 comprised of, for example, a thermosetting resin.

In the semiconductor apparatus for fingerprint recognition produced by the above production steps, the static-electricity drawing wiring 301 having a thickness of about 2  $\mu\text{m}$  has a structure such that it protrudes from the fingerprint-recognizing surface upwardly, as compared to the electrode 2 having a thickness of about 0.5  $\mu\text{m}$ . Therefore, when a finger or any other material which is electrostatically charged is brought closer to the fingerprint-recognizing surface, the static electricity is not discharged into the electrode 2 but into the static-electricity drawing wiring 301. Since the static-electricity drawing wiring 301 is directly connected to the pad electrode 2a as mentioned above, the current discharged is directly drawn out of the semiconductor apparatus for fingerprint recognition through the pad electrode 2a and the wire bonding 4. Therefore, the semiconductor devices and the circuits which are

incorporated into the semiconductor device for fingerprint recognition suffer no damage.

Especially in the semiconductor apparatus for fingerprint recognition which recognizes a fingerprint by reading the charge stored in the electrode 2, the fingerprint-recognizing surface is exposed to the outside without being encapsulated by a resin. Therefore, not only is the fingerprint-recognizing surface exposed to a danger of an external static electricity, but also a finger is inevitably directly in contact with the fingerprint-recognizing surface for achieving the function as a fingerprint recognition device. However, by employing in the fingerprint recognition device the structure formed by the above-mentioned production steps, the discharged current of the static electricity can be prevented from flowing into the internal circuit of the semiconductor apparatus for fingerprint recognition, thus making it possible to prevent a damage of the function of the device due to the static electricity.

Next, the second embodiment of the present invention is described with reference to FIG. 2.

The function as a semiconductor device for fingerprint recognition of the second embodiment is the same as that of the above-mentioned first embodiment, and therefore, only the wiring for drawing static electricity, which is a characteristic feature of the present invention, is described below.

In the present embodiment, a wiring 401 for drawing static electricity (hereinafter, frequently referred to as "static-electricity drawing wiring 401") having a thickness larger than that of an electrode 2 is formed

along the line in the longitudinal direction of the electrode 2 (so that the lower surfaces of the wire 401 and the electrode 2 are aligned in this example). The static-electricity drawing wiring 401 is formed  
5 electrically independently from the electrode 2.

An insulating protecting film 402, such as a passivation film, is formed so as to cover both of the electrode 2 and a pad electrode 2a, and an opening portion is formed in the upper surface of the pad  
10 electrode 2a. In this instance, the thickness of the insulating protecting film 402, such as a passivation film, which is on the side of the upper surface of the electrode 2 is equivalent to the difference in thickness between the electrode 2 and the static-electricity  
15 drawing wiring 401 having a thickness larger than that of the electrode 2. That is, the upper surface of the static-electricity drawing wiring 401 having a thickness larger than that of the electrode 2 is exposed to the outside through the surface of the insulating protecting  
20 film 402. Other portions in the present embodiment are the same as the corresponding portions in the first embodiment of the present invention (FIG. 1).

The semiconductor apparatus for fingerprint  
recognition of the present embodiment can be produced by,  
25 for example, the following method.

First, a semiconductor device, such as a transistor, which functions as a reading circuit, is formed on a semiconductor substrate, and then, aluminum or an aluminum alloy, such as aluminum silicide, is deposited  
30 on the semiconductor substrate by a sputtering process so as to have a thickness of about 1.5  $\mu\text{m}$ .

Then, a resist film for the patterns of a static-electricity drawing wiring and at least one pad electrode is formed by patterning by means of a photolithography process, and subjected to etching, such as RIE, so that a static-electricity drawing wiring comprised of aluminum or the like is formed so as to be disposed between electrodes which are formed by patterning in the subsequent step so that they are arranged in a matrix form. At the same time, at least one pad electrode is formed in a form such that it is connected to the static-electricity drawing wiring.

Next, a Ti layer or a stacked film, such as a Ti/TiN/Ti film, is deposited by, for example, a sputtering process so such that it is connected to the above semiconductor device, and further, aluminum or an aluminum alloy, such as aluminum silicide, is deposited by a sputtering process so that the total thickness of the resultant film becomes about 0.5  $\mu\text{m}$ .

Then, a resist film for the patterns of the above-mentioned static-electricity drawing wiring and at least one pad electrode, an electrode, and a pad electrode for taking a signal out or the like is formed by patterning by means of a photolithography process, and subjected to etching, such as RIE, to thereby effect patterning so that a stacked film comprised of a barrier metal layer, such as a Ti layer, aluminum and the like is left on the static-electricity drawing wiring and at least one pad electrode, and on the remaining region, the electrode and the pad electrode for taking a signal out or the like are arranged in a matrix form.

Next, an insulating film, such as a stacked film of

silicon nitride or silicon oxide, is deposited by, for example, a CVD process so as to have a thickness of about 3  $\mu\text{m}$ , and the surface of the resultant insulating film is polished by a chemical mechanical polishing (hereinafter, referred to simply as "CMP") process until the above-mentioned static-electricity drawing wiring is exposed to the outside, to thereby form an insulating protecting film 402. Then, an opening portion through which the pad electrode 2a is exposed to the outside is formed in the insulating protecting film 402 by patterning. The subsequent steps for production in the present embodiment are the same as the corresponding steps in the first embodiment of the present invention.

In the semiconductor apparatus for fingerprint recognition of the second embodiment, the static-electricity drawing wiring having a thickness of about 2  $\mu\text{m}$  has a structure such that it protrudes from the fingerprint-recognizing surface upwardly, as compared to the electrode having a thickness of about 0.5  $\mu\text{m}$ , and, in addition, the static-electricity drawing wiring is exposed to the outside through the surface of the semiconductor apparatus for fingerprint recognition. Therefore, when a finger or any other material which is electrostatically charged is brought closer to the fingerprint-recognizing surface, the static electricity is not discharged into the electrode but into the static-electricity drawing wiring. (The effect of drawing static electricity in the second embodiment is larger than that in the first embodiment by a magnitude corresponding to the fact that the static-electricity drawing wiring is exposed to the outside through the

surface of the semiconductor apparatus for fingerprint recognition.)

Since the static-electricity drawing wiring 401 is directly connected to the pad electrode 2a as mentioned above, the current discharged is directly drawn out of the semiconductor apparatus for fingerprint recognition through the pad electrode 2a and the wire bonding 4. Therefore, the semiconductor devices and the circuits which are incorporated into the semiconductor apparatus for fingerprint recognition suffer no damage.

Further, from the viewpoint of facilitating the recognition of a fingerprint, it is desired that a finger is in a ground potential. When a finger is in contact with the fingerprint-recognizing surface of the semiconductor apparatus for fingerprint recognition, the finger is also in contact with the static-electricity drawing wiring at the same time. Therefore, by making the static-electricity drawing wiring be in a ground potential, it is possible to surely render the finger be in a ground potential.

Next, the third embodiment of the present invention is described with reference to FIG. 3.

The function as a semiconductor apparatus for fingerprint recognition of the third embodiment is the same as that of the above-mentioned first embodiment, and therefore, only the wiring for drawing static electricity, which is a characteristic feature of the present invention, is described below.

In the present embodiment, a wiring 501 for drawing static electricity (hereinafter, frequently referred to as "static-electricity drawing wiring 501") having a

thickness larger than that of an electrode 2 is formed along the line in the longitudinal direction of the electrode 2 (so that the lower surfaces of the wiring 501 and the electrode 2 are aligned in this example). The static-electricity drawing wiring 501 is formed electrically independently from the electrode 2.

An insulating protecting film 502, such as a passivation film, is formed so as to cover both of the electrode 2 and a pad electrode 2a, and an opening portion is formed in the upper surface of the pad electrode 2a. In the present embodiment, the upper portion of the static-electricity drawing wiring 501 having a thickness larger than that of the electrode 2 protrudes from the surface of the insulating protecting film 502. Other portions in the present embodiment are the same as the corresponding portions in the second embodiment of the present invention (FIG. 2).

The semiconductor apparatus for fingerprint recognition of the present embodiment can be produced by, for example, the following method.

First, a semiconductor device, such as a transistor, which functions as a reading circuit, is formed on a semiconductor substrate, and then, aluminum or an aluminum alloy, such as aluminum silicide, is deposited on the semiconductor substrate by a sputtering process so as to have a thickness of about 1.5  $\mu\text{m}$ .

Then, a resist film for the patterns of a static-electricity drawing wiring and at least one pad electrode is formed by patterning by means of a photolithography process, and subjected to etching, such as RIE, so that a static-electricity drawing wiring comprised of aluminum

or the like is formed so as to be disposed between electrodes which are formed by patterning in the subsequent step so that they are arranged in a matrix form. At the same time, at least one pad electrode is  
5 formed in a form such that it is connected to the static-electricity drawing wiring.

Next, a Ti layer or a stacked film, such as a Ti/TiN/Ti film, is deposited by, for example, a sputtering process so such that it is connected to the  
10 above semiconductor device, and further, aluminum or an aluminum alloy, such as aluminum silicide, is deposited by a sputtering process so that the total thickness of the resultant film becomes about 0.5  $\mu\text{m}$ .

Then, a resist film for the patterns of the above-mentioned static-electricity drawing wiring and at least  
15 one pad electrode, an electrode, and a pad electrode for taking a signal out or the like is formed by patterning by means of a photolithography process, and subjected to etching, such as RIE, to thereby effect patterning so  
20 that a stacked film comprised of a barrier metal layer, such as a Ti layer, aluminum and the like is left on the static-electricity drawing wiring and at least one pad electrode, and on the remaining region, the electrode and the pad electrode for taking a signal out or the like are  
25 arranged in a matrix form.

Next, an insulating film, such as a stacked film of silicon nitride or silicon oxide, is deposited by, for example, a CVD process so as to have a thickness of about 3  $\mu\text{m}$ , and the surface of the resultant insulating film is  
30 polished by a CMP process until the above-mentioned static-electricity drawing wiring is exposed to the



outside, to thereby form an insulating protecting film 502. Then, an opening portion through which the pad electrode 2a is exposed to the outside is formed in the insulating protecting film 502 by patterning. The steps  
5 up to now in the present embodiment are the same as the corresponding steps in the second embodiment of the present invention.

Then, the upper surface of the insulating protecting film 502 is thoroughly subjected to etching by, for  
10 example, an RIE technique so that the about 0.5  $\mu\text{m}$ -thick insulating protecting film from the upper surface thereof is etched. Thus, the thickness of the resultant insulating protecting film is smaller than that of the insulating protecting film shown in FIG. 2 by about 0.5  
15  $\mu\text{m}$ , and therefore, the upper portion of the static-electricity drawing wiring 501 protrudes from the insulating protecting film 502 by about 0.5  $\mu\text{m}$  which corresponds to the thickness of the etched film. The subsequent steps for production in the present embodiment  
20 are the same as the corresponding steps in the first embodiment of the present invention.

The semiconductor apparatus for fingerprint recognition of the third embodiment has a structure such that the static-electricity drawing wiring 501 is exposed  
25 to the outside and protrudes upwardly from the fingerprint-recognizing surface. Therefore, when a finger or any other material which is electrostatically charged is brought closer to the fingerprint-recognizing surface, the static electricity is not discharged into  
30 the electrode 2 but surely into the static-electricity drawing wiring 501. Thus, the static electricity

discharged does not cause the semiconductor devices and the circuits which are incorporated into the semiconductor apparatus for fingerprint recognition to be damaged.

5 Further, as mentioned above, the semiconductor apparatus for fingerprint recognition has a structure such that the static-electricity drawing wiring 501 is exposed to the outside and protrudes upwardly from the fingerprint-recognizing surface. Therefore, by making  
10 the static-electricity drawing wiring be in a ground potential, a finger in contact with the fingerprint-recognizing surface is surely in contact with the static-electricity drawing wiring and made be in a ground potential, thus rendering it possible to stably and  
15 surely perform the fingerprint recognition.

By virtue of having a unique structure such that the static-electricity drawing wiring protrudes upwardly from the electrode on the substrate, the semiconductor apparatus of the present invention is advantageous in  
20 that, when a finger or any other material which is electrostatically charged is brought closer to the substrate, the static electricity is not discharged into the electrode but into the static-electricity drawing wiring and then drawn out of the semiconductor apparatus,  
25 so that the semiconductor devices, the circuits and the like which are connected to the electrode can be prevented from suffering a damage due to the static electricity and from losing the functions thereof.

Especially in the semiconductor apparatus for  
30 fingerprint recognition of the present invention, when a finger which is electrostatically charged is brought

closer to the fingerprint-recognizing surface, by virtue  
of having the above unique structure, the static  
electricity is not discharged into the electrode but into  
the static-electricity drawing wiring and then drawn out  
5 of the semiconductor apparatus, so that the semiconductor  
devices, the circuits and the like which are connected to  
the electrode can be prevented from suffering a damage  
due to the static electricity and from losing the  
functions thereof.

WHAT IS CLAIMED IS:

1. A semiconductor apparatus, comprising:

a substrate having a transistor;

5 a first electrode formed on said substrate and  
connected to said transistor;

a second electrode formed on said substrate and  
electrically separated from said first electrodes; and

10 an insulating film formed on said substrate so as to  
cover said first electrode,

wherein, when a plane of said insulating film which  
is not on a side of said substrate is taken as a first  
plane, a surface facing said first plane of said first  
electrode is taken as a first surface, and a surface  
15 facing said first plane of said second electrode is taken  
as a second surface, a distance between a surface of said  
substrate and said second surface is larger than a  
distance between the surface of said substrate and said  
first surface.

20

2. The semiconductor apparatus according to claim 1,  
wherein said second surface is substantially equivalent  
to a surface of said insulating film.

25

3. The semiconductor apparatus according to claim 1,  
wherein the distance between the surface of said  
substrate and said second surface is larger than a  
distance between the surface of said substrate and the  
surface of said insulating film.

30

4. The semiconductor apparatus according to claim 1,

wherein said second electrodes is fixed in a constant potential.

5     5.    The semiconductor apparatus according to claim 1,  
wherein a plurality of said first electrodes are arranged  
in a matrix form, and said second electrode is disposed  
between said plurality of first electrodes.

10    6.    The semiconductor apparatus according to claim 5,  
wherein a plurality of said second electrodes are  
arranged in a matrix form.

15    7.    The semiconductor apparatus according to claim 1,  
wherein said first electrode is connected to a first  
terminal of said transistor, and a second terminal of  
said transistor is connected to a bit line and a  
capacitance element to which a potential is applied.

20    8.    The semiconductor apparatus according to claim 2,  
wherein said second electrode is fixed in a constant  
potential.

25    9.    The semiconductor apparatus according to claim 3,  
wherein said second electrode is fixed in a constant  
potential.

30    10.   The semiconductor apparatus according to claim 1,  
wherein said second electrode is electrically connected  
to a pad electrode which is connected to a lead for  
taking a signal out.

11. A semiconductor apparatus for recognizing a fingerprint, comprising:

a semiconductor substrate having a transistor;

5 a first electrode formed on said semiconductor substrate and connected to said transistor;

a second electrode formed on said semiconductor substrate and electrically separated from said first electrode; and

10 an insulating film formed on said semiconductor substrate so as to cover said first electrode,

wherein, when a plane of said insulating film on which said fingerprint is placed is taken as a first plane, a surface facing said first plane of said first electrode is taken as a first surface, and a surface facing said first plane of said second electrode is taken as a second surface, a distance between a surface of said semiconductor substrate and said second surface is larger than a distance between the surface of said semiconductor substrate and said first surface.

20

12. The semiconductor apparatus according to claim 11, wherein said second surface is substantially equivalent to a surface of said insulating film.

25

13. The semiconductor apparatus according to claim 11, wherein the distance between the surface of said semiconductor substrate and said second surface is larger than a distance between the surface of said semiconductor substrate and the surface of said insulating film.

30

14. The semiconductor apparatus according to claim 11,

wherein said second electrode is fixed in a constant potential.

15. The semiconductor apparatus according to claim 11,  
5 wherein a plurality of said first electrodes are arranged in a matrix form, and said second electrode is disposed between said plurality of first electrodes.

16. The semiconductor apparatus according to claim 15,  
10 wherein a plurality of said second electrodes are arranged in a matrix form.

17. The semiconductor apparatus according to claim 11,  
15 wherein said first electrode is connected to a first terminal of said transistor, and a second terminal of said transistor is connected to a bit line and a capacitance element to which a potential is applied.

18. The semiconductor apparatus according to claim 12,  
20 wherein said second electrodes is fixed in a constant potential.

19. The semiconductor apparatus according to claim 13,  
25 wherein said second electrodes is fixed in a constant potential.

20. The semiconductor apparatus according to claim 11,  
wherein said second electrodes is electrically connected to a pad electrode which is connected to a lead for  
30 taking a signal out.

# ABSTRACT

A semiconductor apparatus, which comprises: a substrate having a transistor; a first electrode formed on the substrate and connected to the transistor; a  
5 second electrode formed on the substrate and electrically separated from the first electrode; and an insulating film formed on the substrate so as to cover the first electrode, wherein, when a plane of the insulating film which is not on a side of the substrate is taken as a  
10 first plane, a surface facing the first plane of the first electrode is taken as a first surface, and a surface facing the first plane of the second electrode is taken as a second surface, a distance between a surface of the substrate and the second surface is larger than a  
15 distance between the surface of the substrate and the first surface. By virtue of having the above unique structure, the semiconductor apparatus of the present invention is advantageous in that, when a finger or any other material which is electrostatically charged is  
20 brought closer to the substrate, the static electricity is not discharged into the electrode but into the static-electricity drawing wiring and then drawn out of the semiconductor device, so that the semiconductor devices, the circuits and the like which are connected to the  
25 electrode can be prevented from suffering a damage due to the static electricity and from losing the functions thereof.



FIGs. 1 to 4

1; 51: SEMICONDUCTOR CHIP

2; 52: ELECTRODE

2a; 52a: PAD ELECTRODE

5 3; 402; 502; 53: PROTECTING FILM

301; 401; 501: WIRING FOR DRAWING STATIC ELECTRICITY

4; 54: WIRE BONDING

5; 55: LEAD

6; 56: MOLD RESIN

10

FIG. 5A

7: FINGER

10: SUBSTRATE

20: BARRIER METAL

15 21: ELECTRODE

30: PROTECTING FILM

70: UNEVENNESS OF FINGERPRINT

FIG. 1

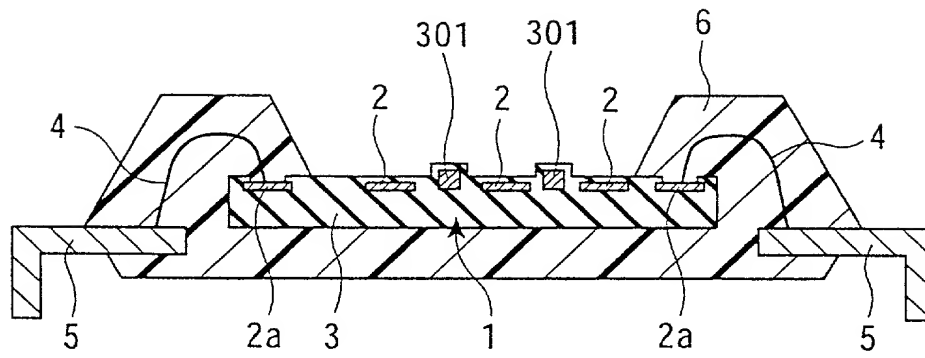


FIG. 2

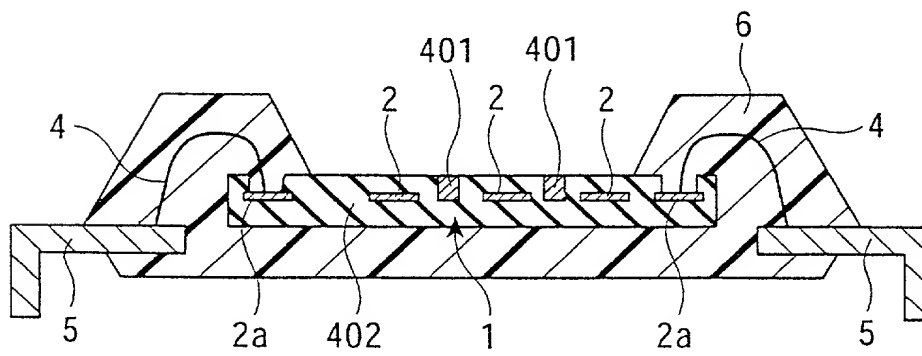


FIG. 3

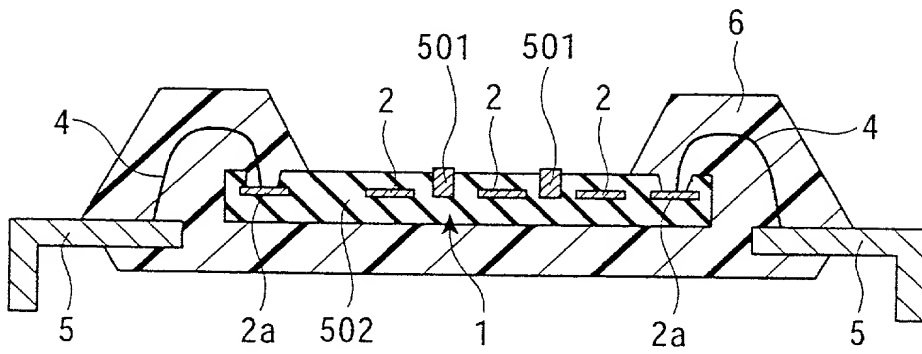
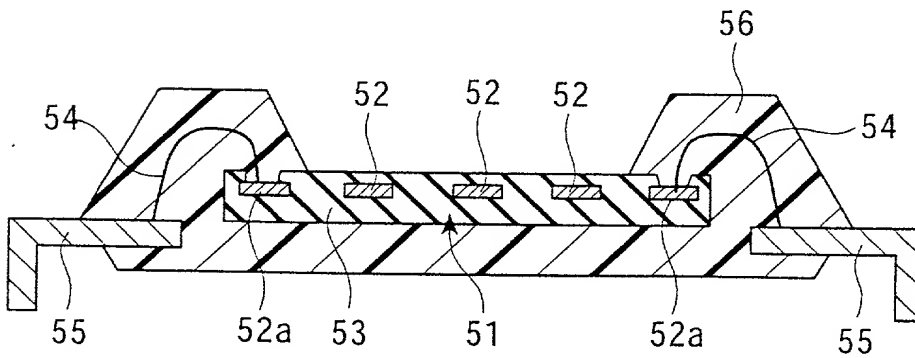
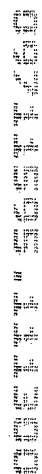
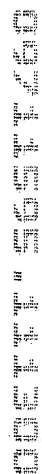


FIG. 4



[illegible][illegible]

# DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

## 特許出願宣言書及び委任状

### Japanese Language Declaration

### 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

上記発明の明細書（下記の欄でx印がついていない場合は、本書に添付）は、

☐ \_\_月\_\_日に提出され、米国出願番号または特許協定条約国際出願番号を\_\_\_\_とし、  
（該当する場合）\_\_\_\_に訂正されました。

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

私は、連邦規則法典第37編第1条56項に定義されたとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

**“SEMICONDUCTOR APPARATUS FOR FINGERPRINT RECOGNITION”**

the specification of which is attached hereto unless the following box is checked:

☐ was filed on \_\_\_\_\_ as **United States Application Number** or PCT International Application Number \_\_\_\_\_ and was amended on \_\_\_\_\_ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基づき下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約365(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or Inventor's certificate or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or Inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

外国での先行出願

P11-323051 Japan November 12, 1999

(Number) (番号)	(Country) (国名)	(Day Month Year Filed) (出願年月日)
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(Number) (番号)	(Country) (国名)	(Day Month Year Filed) (出願年月日)
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Priority Not Claimed

優先権主張なし

(Number)	(Country)	(Day Month Year Filed)
----------	-----------	------------------------

(Number)	(Country)	(Day Month Year Filed)
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私は、第35編米国法典119条(e)項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) [出願番号]	(Filing Date) [出願日]
-----------------------------	------------------------

(Application No.) [出願番号]	(Filing Date) [出願日]
-----------------------------	------------------------

私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)に基づき権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) or 365(c) of an PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application No.)  
[出願番号]

(Filing Date)  
[出願日]

(Status: patented, pending, abandoned)  
(現況: 特許許可済、係属中、放棄済)

Application No.)  
[出願番号]

(Filing Date)  
[出願日]

(Status: patented, pending, abandoned)  
(現況: 特許許可済、係属中、放棄済)

私は、私自身の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じることに基づく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

委任状: 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁理士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named Inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

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第二共同発明者	Full name of third joint inventor, if any:
発明者の署名                      日付	Inventor's signature                      Date
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私書箱	Post Office Address

## Japanese Language Declaration

(日本語宣言書)